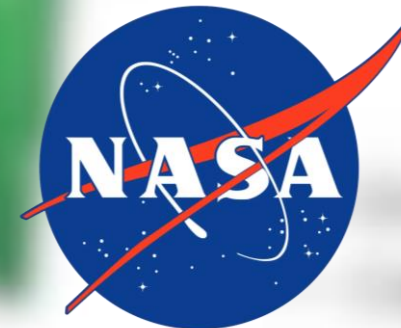


# The power of GEDI: Investigate the efficacy of spaceborne Lidar to model biodiversity and characterize habitat heterogeneity at the continental and global scales

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Funded by NASA Earth Science Division New (Early Career) Investigator Program (NIP)  
80NSSC21K0936

# Team Members



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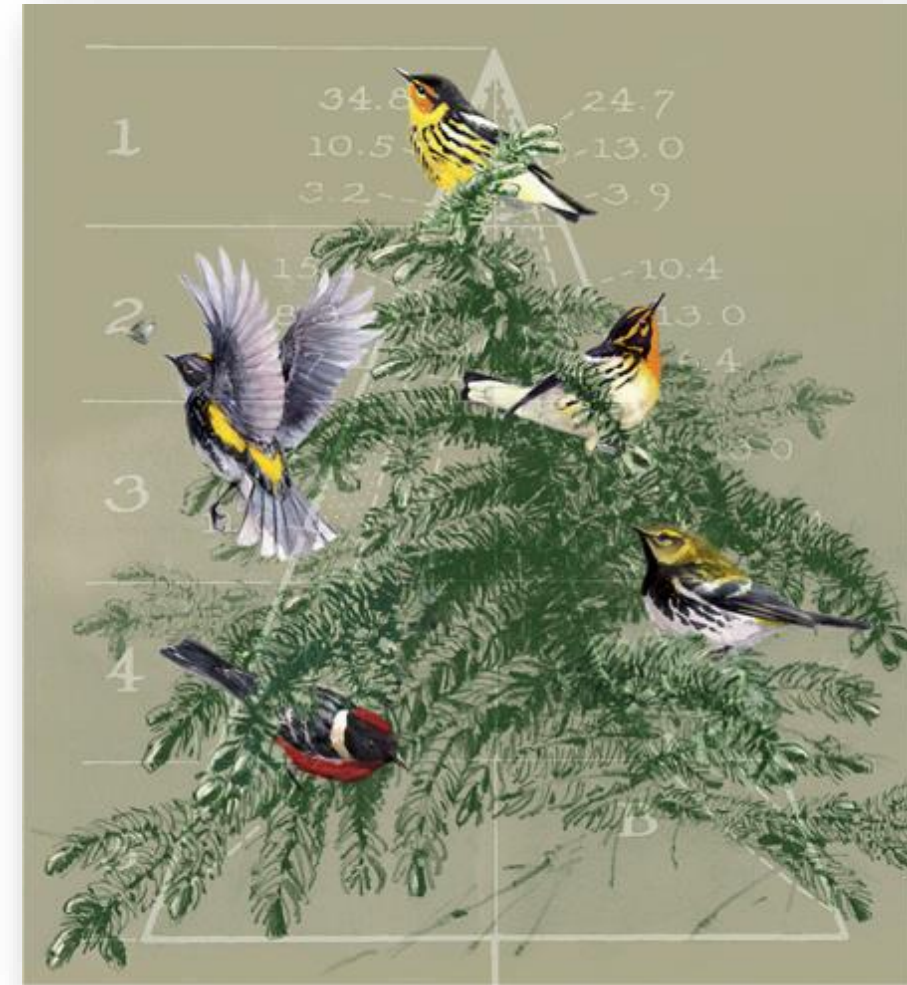


Smithsonian



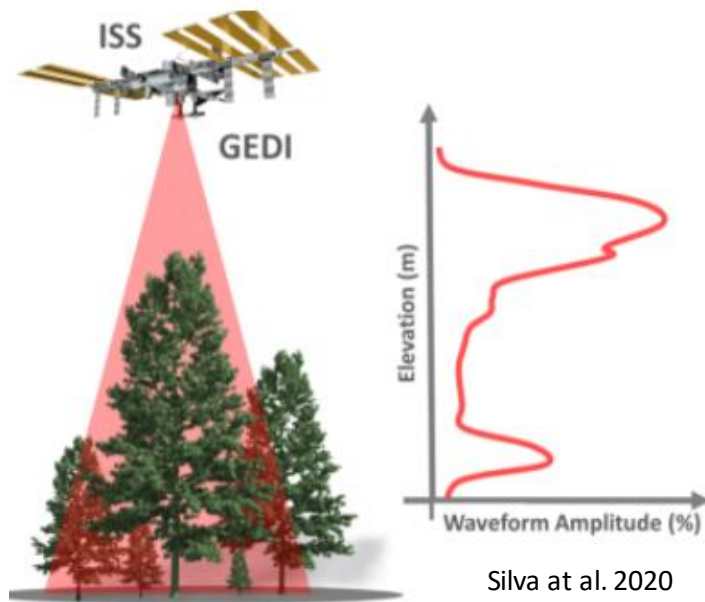
# Background

- Vegetation's three-dimensional (3-D) structure is a key predictor of biodiversity.
- Vegetation vertical structure, often difficult to observe by optical remote sensing instruments, is a critical but rarely examined component of habitat heterogeneity
- Most previous studies are limited to relatively small spatial extents or focused only on canopy height-related metrics
- Full-waveform Lidar sensors such as Land Vegetation and Ice Sensor (LVIS) provide us a window to gauge GEDI's capability.
- The availability of GEDI data provides an opportunity to evaluate the importance of habitat vertical structure on biodiversity at broad scales.

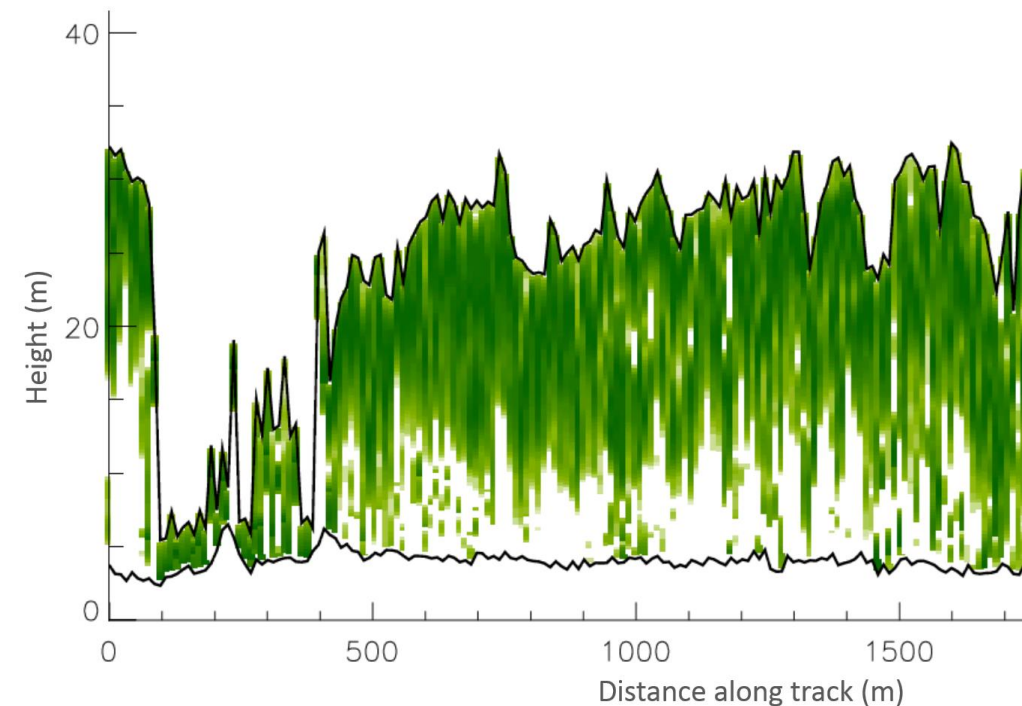
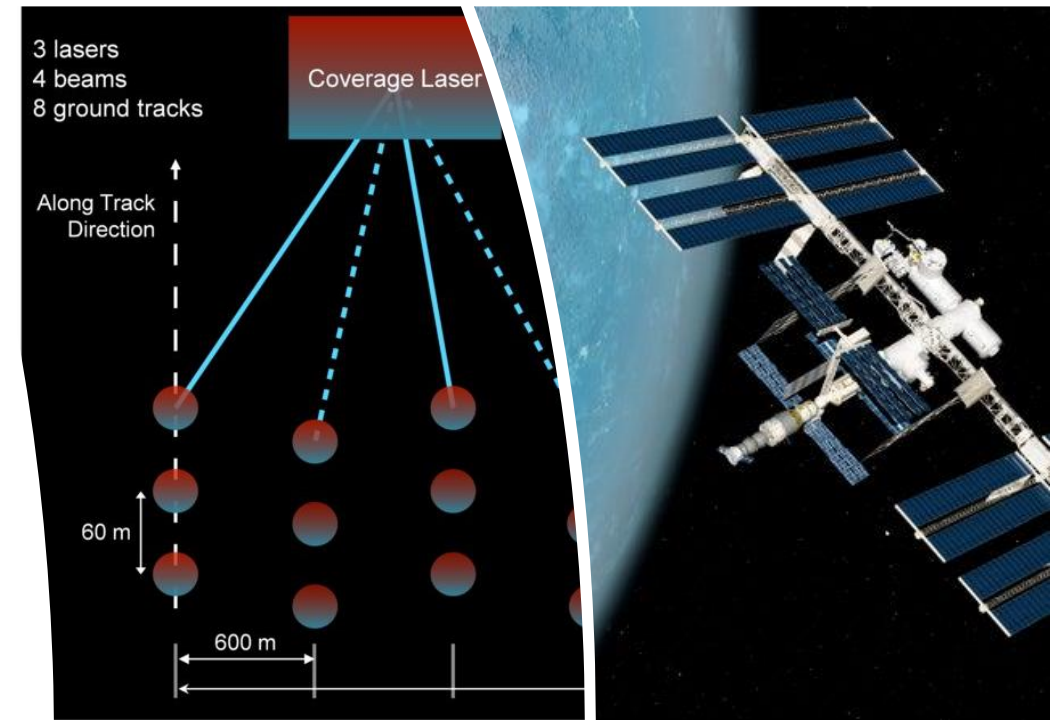




- **Project Progress:**
- 1. **Model forest tree richness** using ForestGEO and NEON forest plot data .
- 2. **Model avian richness** in the continental U.S. using North American Breeding Bird Survey data



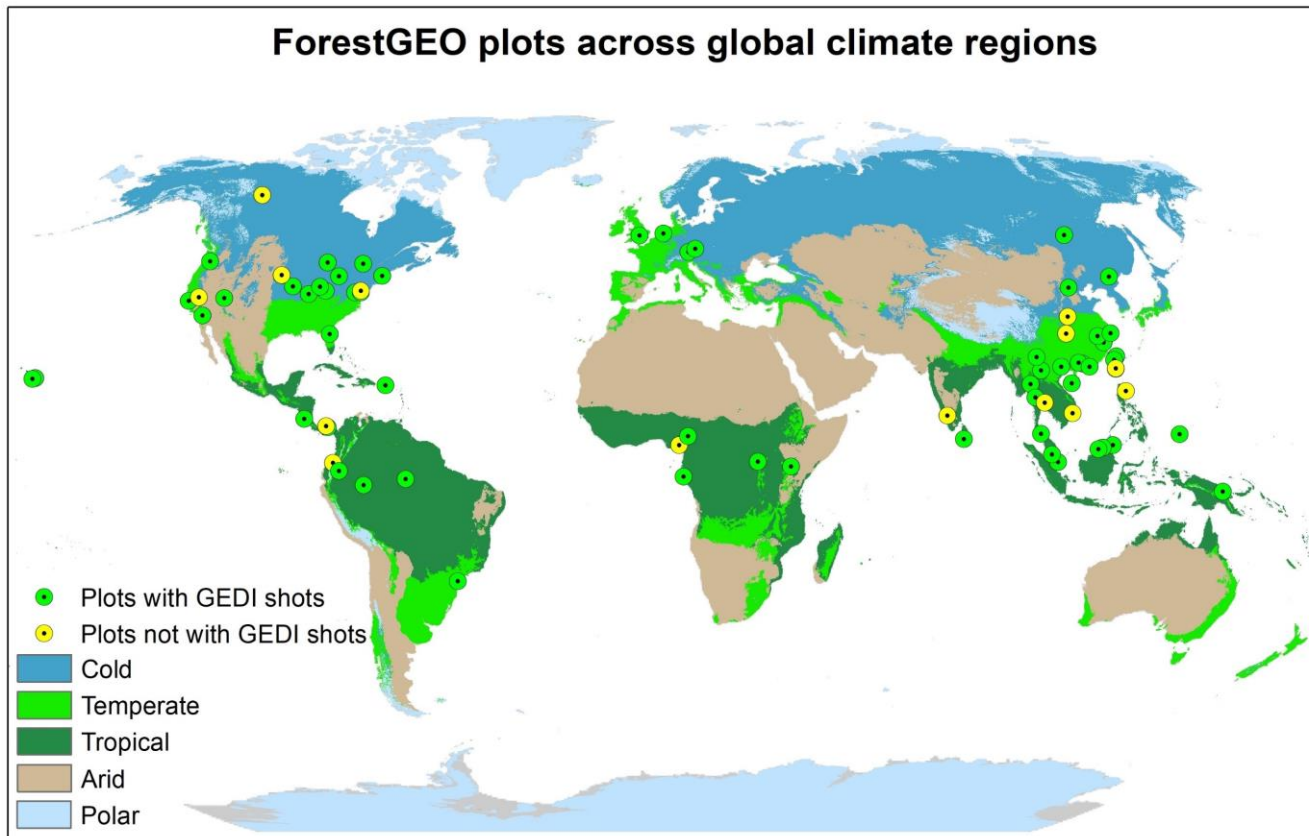
Silva et al. 2020



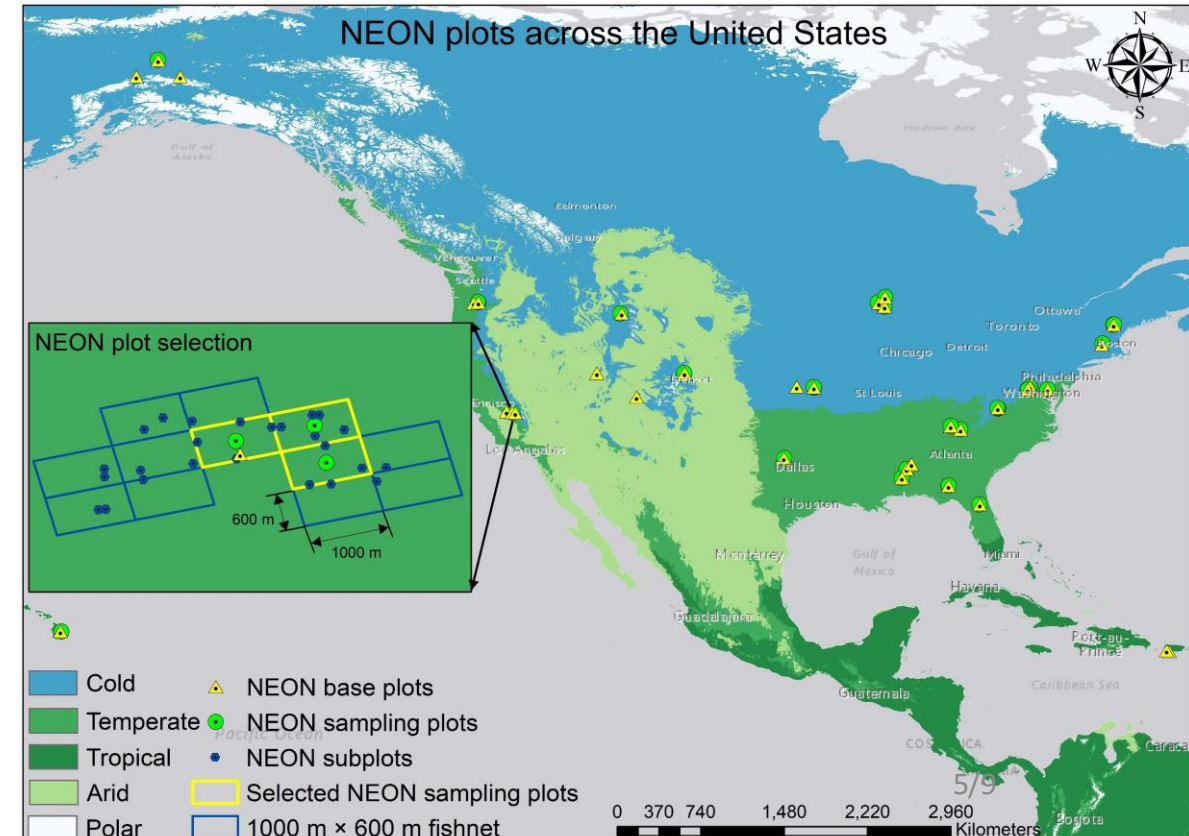
# Modeling Global Forest Tree Biodiversity

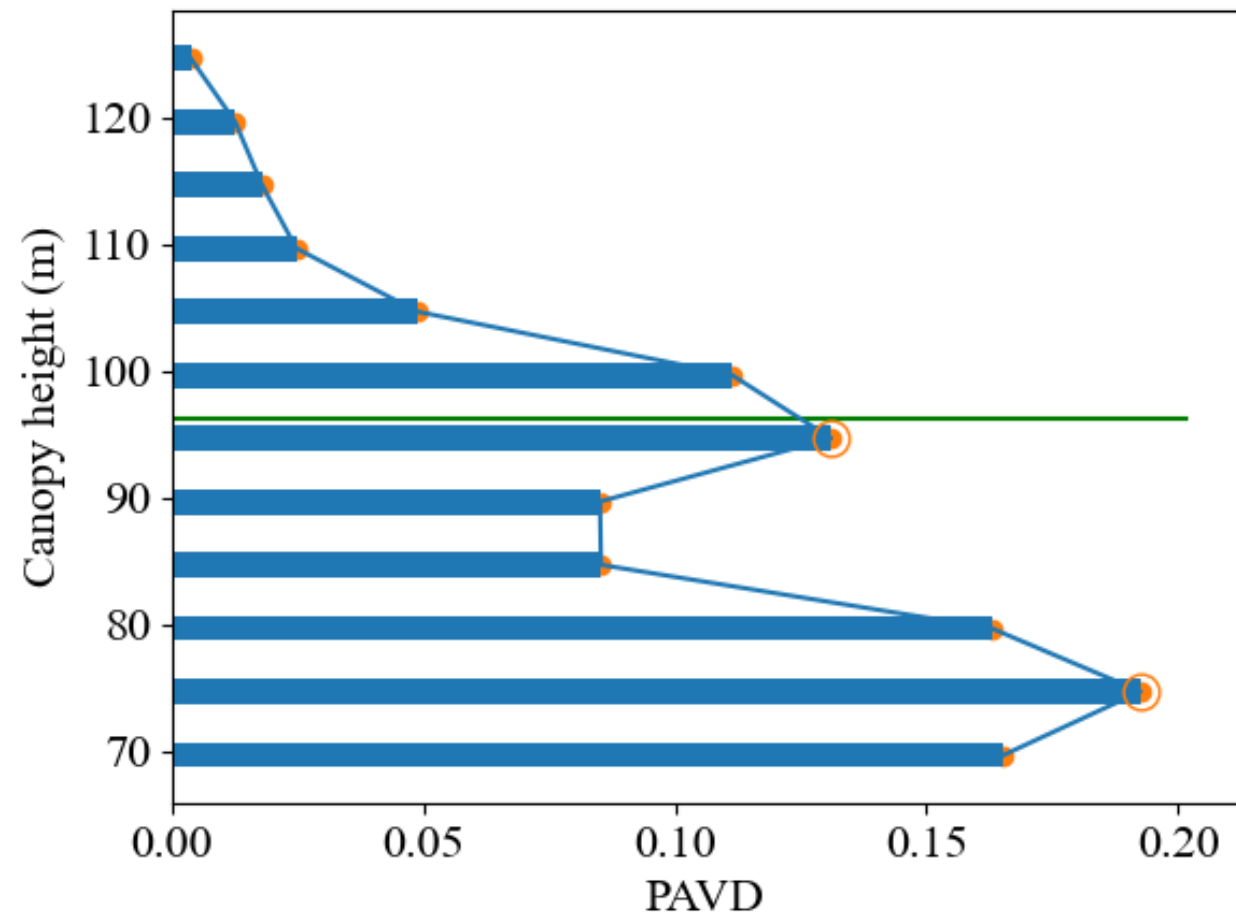
- The Forest Global Earth Observatory (ForestGEO,  $n = 74$ )
- National Ecological Observatory Network (NEON,  $n = 51$ )

ForestGEO plots across global climate regions



NEON plots across the United States





## -Plot Size

## -GEDl L2A Metrics

- Canopy Height (CH, RH98, m)

## -GEDl L2B Metrics

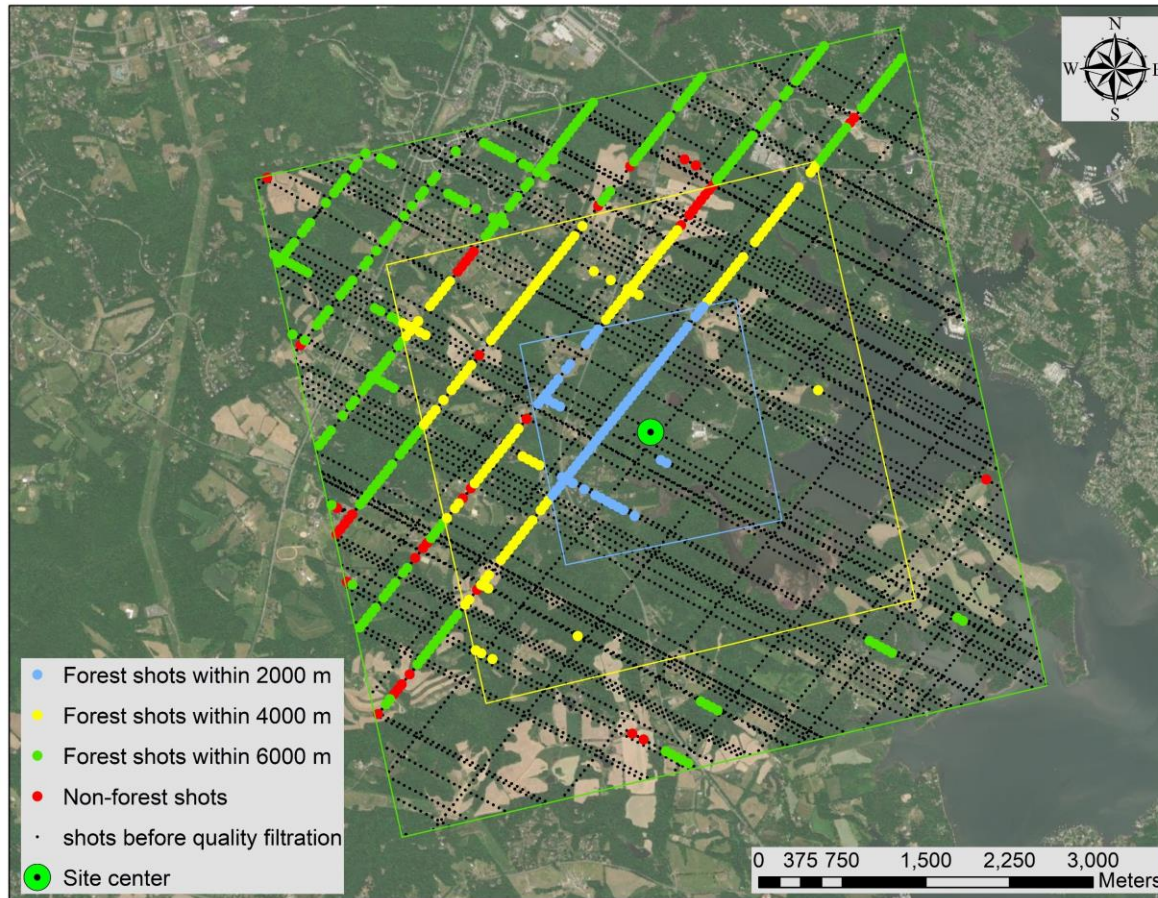
- Plant Area Index (PAI, m<sup>2</sup>/m<sup>2</sup>)
- Foliage Height Diversity (FHD, N/A)
- Plant Area Volume Density (PAVD, m<sup>2</sup>/m<sup>3</sup>)

## -Derivative Canopy Shape Metrics

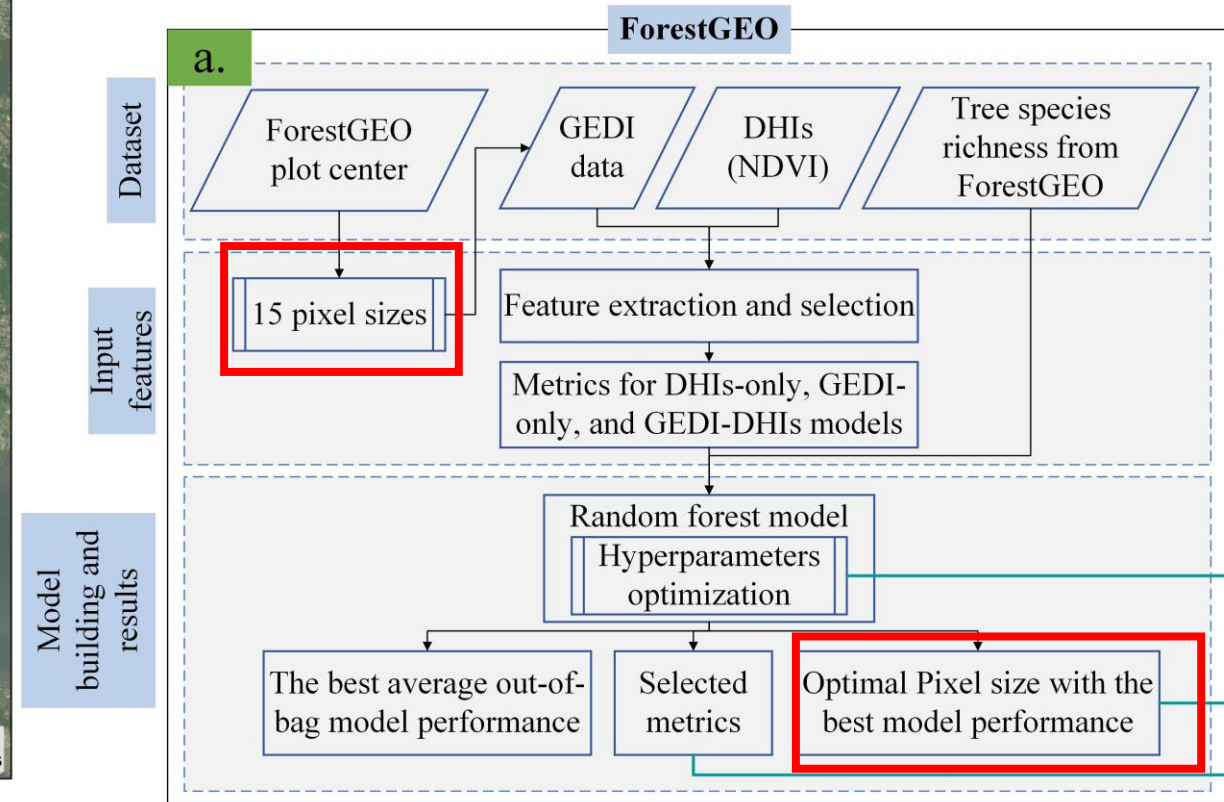
- Number of PAVD foliage layers
  - For example (left figure): two PAVD peaks
- PAVD canopy ratio: sum of PAVD in the top strata / sum of PAVD in bottom strata
  - For example (left figure):  $0.22 / 0.66 = 0.33$



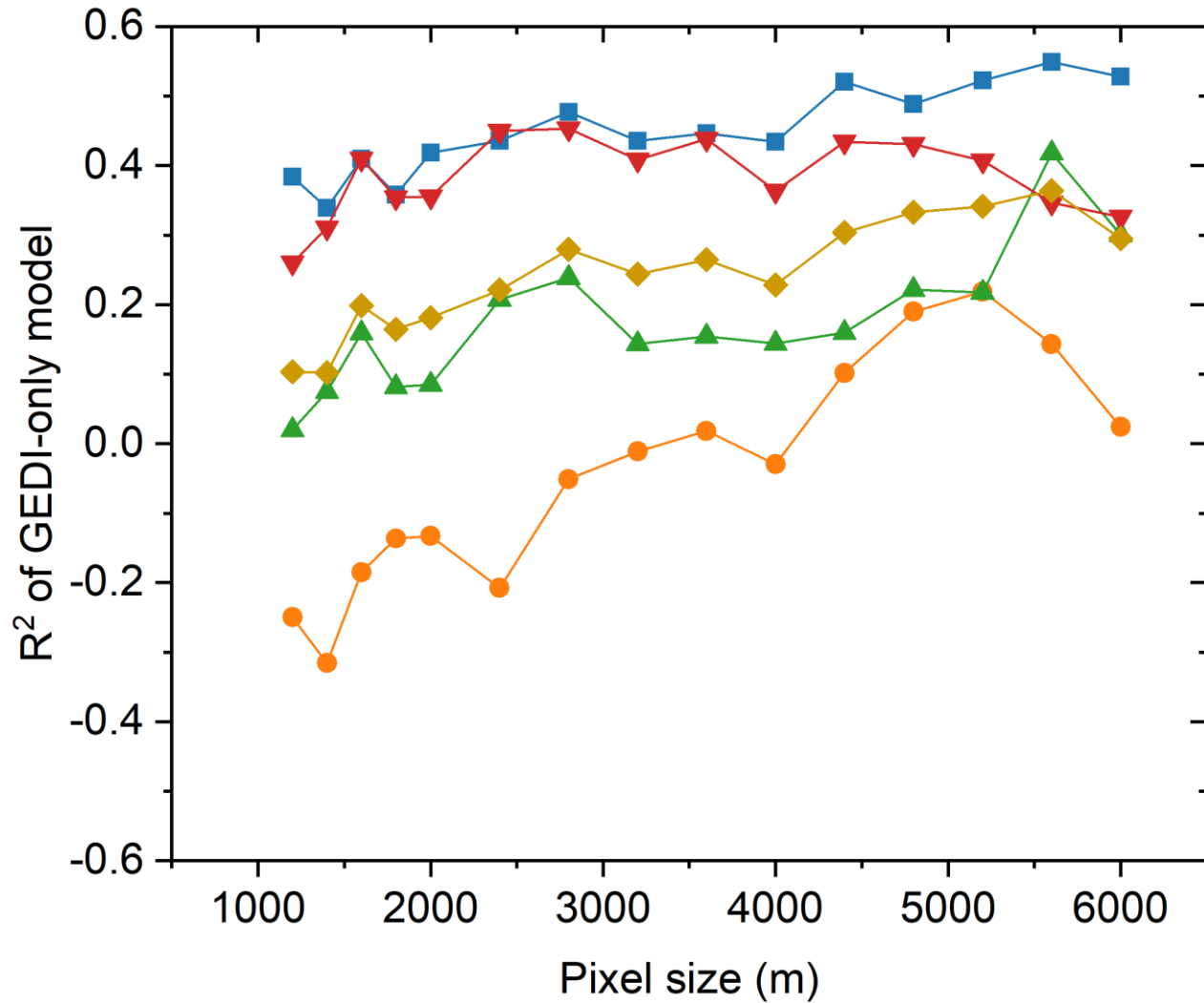
- Tested 15 buffer sizes ranging between 1200 m – 6000 m



ForestGEO plot located at Smithsonian Environmental Research Center (Edgewater, MD) with 2000 m (blue), 4000 m (yellow), and 6000 m (green) buffer sizes.



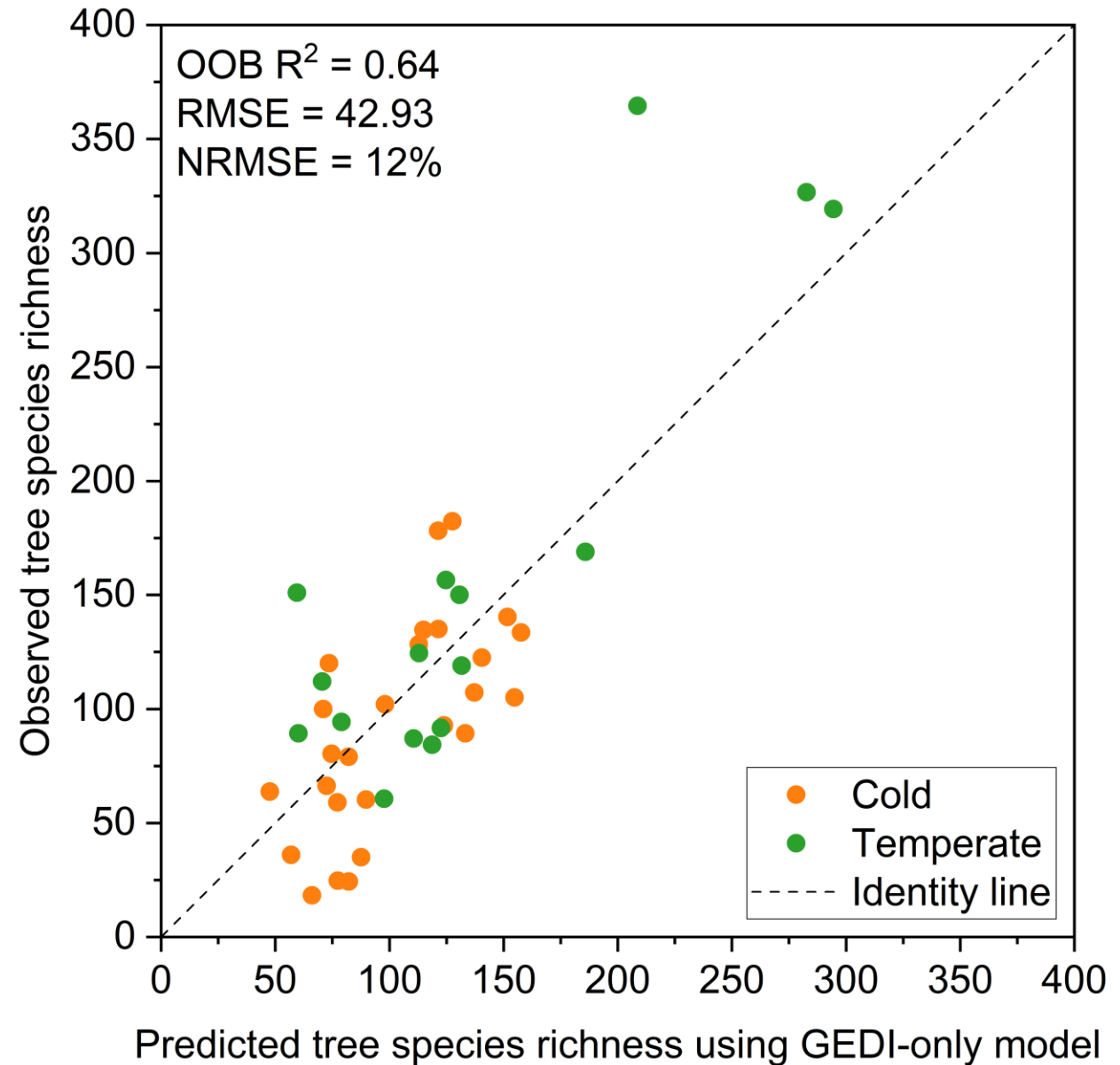
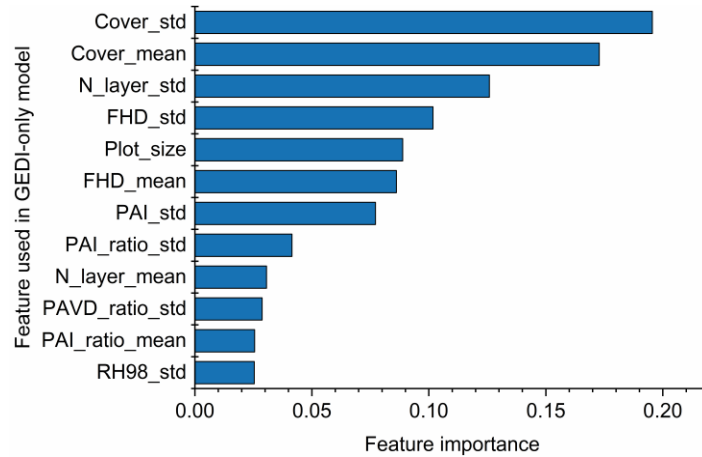
## GEDI tree richness models



- Optimal buffer size at 5600m
- On average global models perform better than stratified models in individual climate zones
- Tropical climate models perform better than the rest of climate zones



# NEON model performance

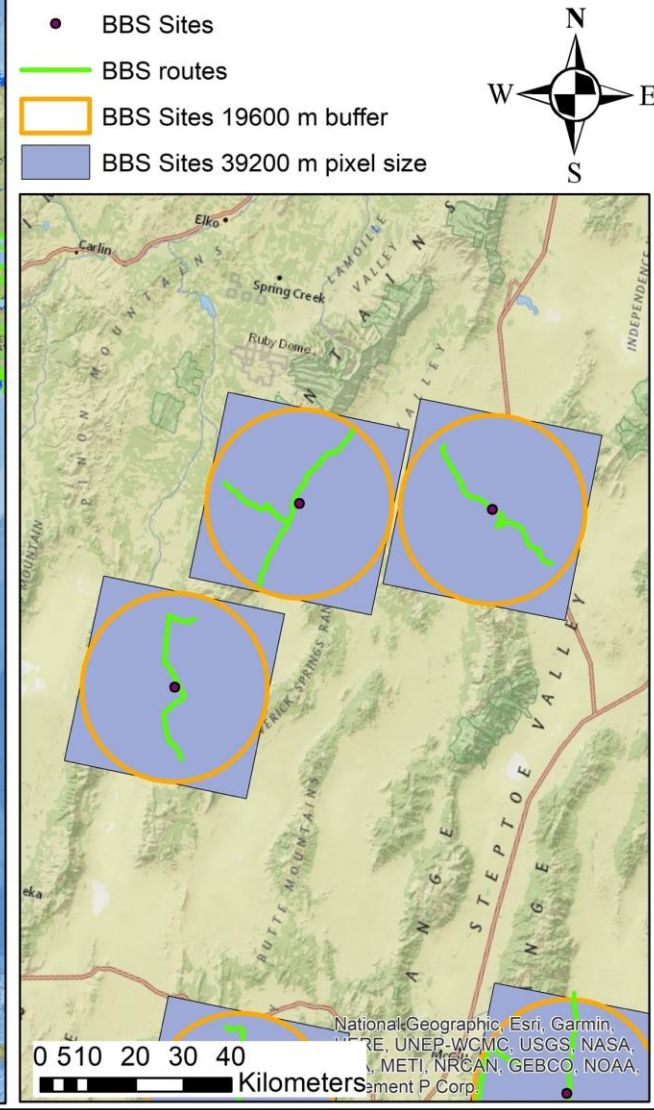


# Modeling North American breeding bird richness

Avian guild by habitat , nesting, and migration types	
1	Woodland
2	Urban
3	Early succession Scrub
4	Grassland
5	Nesting Ground nesting
6	Nesting Cavity
7	Nesting Mid-story
8	Nesting Open cup
9	Permanent resident
10	Neotropical migrant
11	Short distance migrants



The North American Breeding Bird Survey (BBS) routes





# Avian Diversity Prediction Using Global Ecosystem Dynamics Investigation (GEDI) Data

Jin XU<sup>1</sup>, Laura Farwell<sup>2,3</sup>, Volker C. Radeloff<sup>2</sup>, Melissa Songer<sup>1</sup>, Qiongyu Huang<sup>1</sup>

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<sup>2</sup> Forest and Wildlife Ecology Department, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706

<sup>3</sup> Pacific Birds Habitat Joint Venture



**NASA NIP Project:** The power of GEDI: Investigate the efficacy of spaceborne Lidar to model biodiversity and characterize habitat heterogeneity at the continental and global scales. PI: Qiongyu Huang. Proposal/Award Number: 80NSSC21K0936

## Introduction

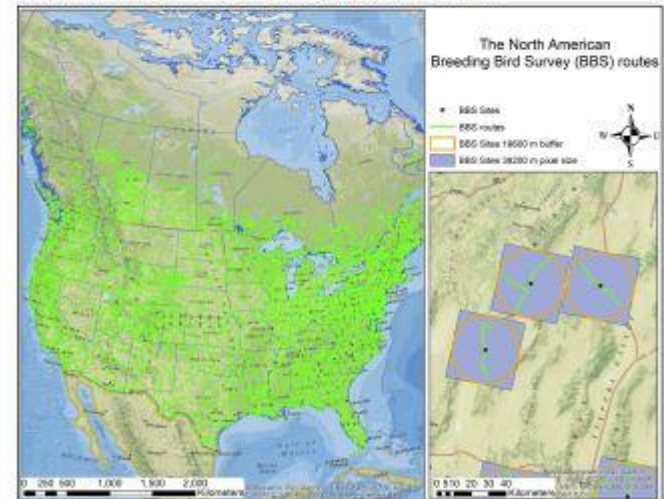
- Biodiversity in most ecosystems is a function of resources and space.
- The structural heterogeneity of habitat in the vertical dimension provides diverse ecological niches that partition space and resources and lead to high biodiversity.
- For birds, the vertical distribution of vegetation is a crucial characteristic that determines many aspects of their habitat suitability, such as micro-climate, food abundance, and breeding grounds.
- Global Ecosystem Dynamics Investigation (GEDI) instrument has the potential to detect the contribution of the full vertical profile of forest foliage to mapping habitat suitability and biodiversity.

## Objective

- What is the efficacy of space-borne (GEDI) lidar metrics in predicting global avian species richness?
- What is the capacity of the GEDI-based model to predict tree species richness in different climate zones?
- How the model performance varies across different functional guilds?

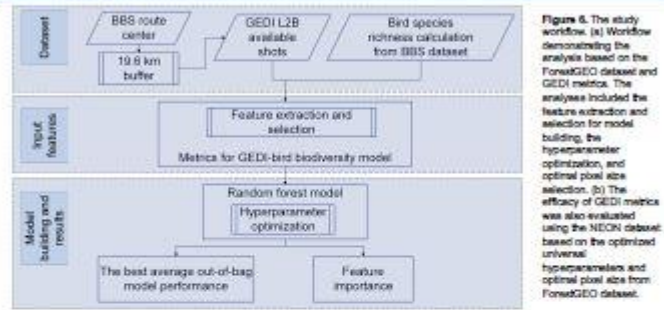
## Data Source

- North American Breeding Bird Survey (BBS) routes dataset



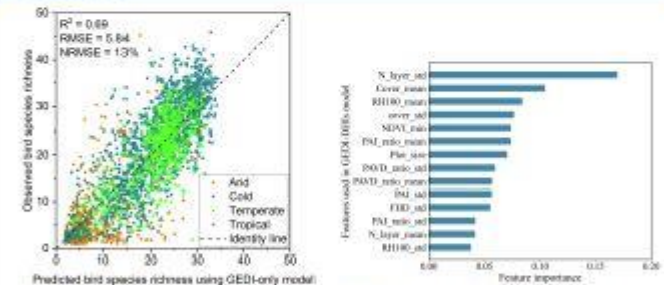
**Figure 1.** BBS start points data (1966 - 2021), BBS route data (1966 - 2002 and 1966 - 2012); we obtained 3796 routes. Routes are roughly 24.5 miles (39.2 km) long, with counting locations placed at approximately half-mile (800-m) intervals for 50 stops.

## Methods



**Figure 5.** The study workflow. (a) Workflow demonstrating the analysis based on the ForestGEO dataset and GEDI metrics. The analyses included the feature extraction and selection for model building, the hyperparameter optimization, and optimal pixel size selection. (b) The efficacy of GEDI metrics was also evaluated using the NEON dataset based on the optimized universal hyperparameters and optimal pixel size from ForestGEO dataset.

## Results



**Figure 7.** Volin plot presenting probability density and the statistics of the number of GEDI shots of ForestGEO plots within a 4000 m pixel size across climate zones.

	All		Arctic		Cold		Temperate	
	R <sup>2</sup>	RMSE	R <sup>2</sup>	RMSE	R <sup>2</sup>	RMSE	R <sup>2</sup>	RMSE
1. Woodland	0.69	5.54	0.39	6.03	0.05	5.05	0.54	4.77
2. Urban	0.67	1.54	0.09	1.50	0.70	1.52	0.50	1.67
3. Nest Cavity	0.56	2.56	0.27	3.06	0.50	2.34	0.27	2.26
4. Nest Mid story	0.56	5.41	0.32	6.41	0.47	4.74	0.46	4.56
5. Nest Open cup	0.52	6.67	0.23	7.00	0.43	6.06	0.50	5.27
6. Mig Neotropical	0.51	5.68	0.17	5.83	0.40	5.44	0.46	5.24
7. Grassland	0.46	2.06	0.25	2.61	0.59	1.62	0.35	0.89
8. Mig Permanent	0.39	2.96	0.21	4.17	0.51	2.13	0.24	2.24
9. Nest Ground low	0.32	3.75	0.07	4.17	0.26	3.57	0.39	3.03
10. Mig Short	0.32	4.37	0.26	5.06	0.21	3.77	0.35	3.56
11. Successional_Scrub	0.28	3.15	0.13	4.93	0.44	2.29	0.26	2.66
12. Wetland Open water	0.22	4.64	0.04	5.96	0.45	4.14	0.20	3.36

Dr. Jin XU's poster  
today 5:00-7:00 PM  
#1-45



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# Thank You!

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